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(54) IMPROVEMENTS IN OR RELATING TO ORTHOPAEDIC APPARATUS

(71) We, TALLINSKY POLITEKHNICHESKY INSTITUT, a Corporation organised and existing under the laws of the USSR of 5 Ekhitayate tee, Tallin, USSR, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to orthopaedic endoapparatus.

According to the present invention, there is provided orthopaedic endoapparatus intended to allow growth of a new live shoulder or hip joint, reconstruction of a deformed joint or restoration of a pathologically dysplastic and congenitally luxated joint, said apparatus comprising a hinge formed by a substantially spherical knob which is engaged in a curved groove of a guide member, the groove being of arcuate cross-section corresponding to that of the spherical knob, the knob being movable along the groove and being capable of limited pivotal movement relative to the guide member, the spherical knob being connected by a curved rod with one operative end of a turnbuckle, the other operative end of which is adjustably connected to a first anchoring means comprising a pair of interconnected, crossed, curved rods, capable of being introduced into a marrow tube, the guide member being attached to one end of a rod, the other end of which is adjustably connected to second anchoring means comprising interconnected, crossed, curved rods, arranged to be secured to the pelvis or the scapula and clavicula.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings; in which:

Figure 1 is a front elevation of an orthopaedic endoapparatus for allowing growth of a new live right joint, preferably a hip joint, for reconstructing a deformed joint for restoring a pathologically dysplastic and congentially luxated joint, the endo apparatus being shown in position for attachment to bones forming the joint;

Figure 2 is a side elevation partly in section of the endoapparatus;

Figure 3 is a section taken on line III—III of Figure 2, with the axes of two turnbuckles of the apparatus being in the plane of the section;

Figure 4 is a section taken on line IV—IV of Figure 3;

Figure 5 is a front elevation of a modified form of the endoapparatus for allowing growth of a new live right joint, preferably in a shoulder joint, the endoapparatus being in position for attachment to the bones forming the shoulder joint; and

Figure 6 is a side elevation partly in section of the endoappartus shown in Figure 5.

The endoapparatus shown in Figures 1 to 4 compriss a hinge 1 (Figures 1, 2) consisting of a spherical knob 2 in sliding engagement with a curved guiding member 3. The curved guiding member 3 has an internal hollow space groove 4 of arcuate cross-section corresponding to the spherical knob 2, the longitudinal axis of the groove 4 being arcuate. The curved guiding member permits limited pivotal movement of the spherical knob 2 about its centre and permits the knob 2 to slide along the arcuate groove 4. The spherical knob 2 is attached to one end of a rod 5, the other end of which passes directly into a clyindrical threaded rod 6 of a turnbuckle 7.

The turnbuckle 7 comprises a sleeve 8 (Figure 3) having flats 9 (Figure 4) for a spanner on the outside thereof.

The sleeve 8 of the turnbuckle 7 has a longitudinal bore thereinside. A middle portion 10 of this bore has a plain cylindrical surface with a diameter D (Figure 4), while end portions 11 and 12 adjoining same have right and left-hand threads, respectively.

Threaded rods 6 and 13 screwed from opposite ends into the sleeve 8 have plain end portions 14 and 15 located inside the sleeve 8, the diameter d (Figure 4) of the end portions 14, 15 being less than the diameter D of the longitudinal bore of the sleeve 8. The rods 6 and 13 are each of longitudinally reduced thickness over a

length which includes all of the plain end portions 14, 15 and part of the adjacent threaded portion of the rod (the length of this part of the threaded portion being approximately equal to the diameter of the threaded portion). The thickness reduction is obtained by cutting a flat in each rod, the width h, h_1 (Figure 4) of the reduced thickness portions being greater than one half of the original diameter *d*. The flats of the two rods are in mutual engagement, while their cylindrical surface portions are in contact with the walls of the middle portion 10 of the sleeve 8.

As the widths h and h_1 of the reduced thickness end portions 14 and 15 exceed half their original diameter d, the rods tend to mutually push each other off the longitudinal axis of the sleeve 8. The reduced thickness end portions 14 and 15 therefore become bent at their base to form thereby a preloaded contact between the rods 6 and 13 in the plane of contact, as well as between the rods 6 and 13 and the sleeve 8 in its plain middle portion 10. The threaded portions 16 and 17 of the rods 13 and 6 are bent away from the longitudinal axis of sleeve 8 to form oppositely directed screw-threaded half-cones, the threads of which wedge with the threads of the sleeve 8 along both its end portions 11 and 12.

Such a construction of the turnbuckle 7 precludes rotation of the rods 6 and 13 relative to each other, at rest as well as over the entire working distance of the turnbuckle, which is equal to half the length of the sleeve 8. It also precludes transverse and longitudinal play between the rods 6 and 13 and between the rods 6 and 13 and the threads of the sleeve 8 and, what is particularly important, precludes any possibility of self-loosening of the connection without the need for any additional locking means. At the same time the tensile, compressive, torsional and twisting strengths of the connection remain equal to those of the cylindrical portions of the rods 6 and 13.

The endoapparatus is fastened to the shoulder or hip bone by a pair of curved anchoring rods 18 and 19 (Figure 2), which are detachably crosswise connected with each other by the rod 18 being passed through an aperture in the rod 19.

The end portion of the threaded rod 13 extending from the sleeve 8 terminates in a toothed segment 20 which is engaged with a projection 21 at the end of the curved rod 18. The other curved rod 19 has a tapered projection 22 which is engaged in a tapered hole at the top of the toothed segment 20, and the curved rod 19 is braced against the toothed segment 20 by a screw 23. As a result there is formed a detachable and adjustable cone-shaped toothed interconnection of the anchoring rods 18 and 19 with the connecting turnbuckle 7. Ends 24 and 25 of the crosswise connected curved rods 18 and 19 extend from the point of intersection in opposite directions, and, on being inserted into a bone tube 26, form on the inside two support areas at one side of the tube 26, while a middle portion 27 of the rod 19 forms a third support area within the bone tube 26 upon the compact layer of its wall on its diametrically opposite side. The rod 19 rests upon the outside surface of the bone tube 26 by a rectangular area 28 (Figures 2 and 3), situated at the base of its tapered projection 22.

By being inserted into the bone tube 26, a pre-load is set up between the two rods 18 and 19 and between the rods and the bone tube 26.

Such a preloaded fixing of the compact layer of the fragile elastic bone with the resiliently interconnected rods 18 and 19 ensures that the bone-to-metal connection will be long-lasting, with a three to ninefold margin of safety for the bone against crushing under conditions of variable stress.

The curved guiding member 3 is intended to limit the possible positions of, and directions of movement of, the spherical knob 2 and is, at its rear side fixedly connected with one end of a threaded rod 29 (Figure 3). The other end of the rod 29 is screwed into a sleeve 30 having a blind threaded bore. On the outer surface of the sleeve 30 there are flats for a spanner. At its open end portion, the sleeve 30 has three longitudinal slits, and this part of the sleeve is surrounded by a clamping collar 31 with a screw 32 which terminates in a drill-bit to be screwed into the pelvis.

By tightening the screw 32 the sleeve 30 is firmly fixed relative to the rod 29.

The sleeve 30 terminates in a spherical knob 33. The spherical knob 33 is held in a seat defined between opposed jaws 34, 35 clamped by a screw 36. When the screw 36 is tightened the distance between the jaw 34 and 35 is narrowed, and the spherical knob 33 is fixed immovably. The jaw 34 terminates in a toothed segment 37 (Figure 2) which is engaged with a projection 38 at the end of a curved rod 39. The curved rod 39 is detachably and crosswise linked with a curved rod 40 by passing the rod 39 through an aperture in the rod 40. The rods 39 and 40 form an anchoring member intended to fix the apparatus mainly to the pelvis. Support areas 41, 42 and 43 (Figure 1) are intended to lean against the bone.

The curved rod 40 has on its end a tapered projection 44 (Figure 3), which is inserted into a tapered aperture in the jaw 35. Through the tapered projection 44, a threaded hole is formed in which the screw 36 is engaged to tighten the jaws 34 and 35. Thus there are formed a detachable and

adjacable cone-shaped and toothed interconnection of the rod 29, coupled with the guiding member 3, to the anchoring member for fixing the apparatus to the pelvis.

Such a construction connecting the figured hinge 1 of the apparatus and the anchoring pair of curved rods 39 and 40 in order to fasten the apparatus to the pelvis, allows the surgeon to set the figured hinge 1 in the right place with respect to the articular fossa, and also allows him to use it as a jack for a sparing resetting of congentially luxated joints in children.

If the apparatus is to be used for growing a new live shoulder joint, it is preferred to change somewhat the anchoring arrangement to fix the apparatus to the clavicula and the scapula, as shown in Figures 5 and 6.

In this case the rear side of the guiding member 3 is connected with a turnbuckle 45 (Figure 5) which connects the figured hinge 1 with an anchoring member for fixing the apparatus to the scapula and clavicula.

The turnbuckle 45 consists of a sleeve 46 having a threaded blind bore thereinside. The closed end of the sleeve is rigidly attached to the rear side of the guiding member 3, and the bore of the sleeve receives a threaded rod 47. The rod 47 is provided with a nut 48 and the end of the rod 47 remote from the sleeve 46 terminates in a flat toothed segment 49. A transverse aperture is provided in the rod 47 at the base of the segment 49. The body of the sleeve 46 has a longitudinal slit, which can be narrowed in order to lock the turnbuckle in a desired position by means of a clamping collar 50 which surrounds the sleeve 46 and which is provided with a clamping screw 51. The screw ends as a drill-bit to be screwed into the bone.

The anchoring member for fixing the apparatus to the scapula and the clavicula consists of three curved rods 52, 53 and 54, which are detachably and adjustably crosswise connected with one another and with the free end of the rod 47 of the turnbuckle 45.

The rod 54 of the anchoring member has, in its middle portion a transverse threaded aperature. One end of the rod 54 is bent into a claw for insertion into the acromical appendage of the scapula, while the other end of this rod is straight and terminates in a tooth-like projection 55, intended to engage the toothed segment 49 of the turnbuckle 45. When the anchoring member is mounted, the rod 54 is placed underneath the rods 52 and 53 extend to the left and to the right, respectively. One end of each of the rods 52 and 53 is divided into an upper and a lower part, both traversed by a transverse aperture. When mounting the rods 52 and 53, they are set with their divided parts on the flat area of the rod 47 of the turnbuckle 45, so that the transverse aperture in the rod 47 coincides with the apertures in the branches of the rods 52 and 53. The respective upper and lower parts of the rods are engaged and the spaced interval between the pairs of upper and lower parts is occupied by the rod 47 of the turnbuckle 45. A screw 56 passes through the aligned apertures into the threaded aperture in the rod 54. Thus, a detachable and adjustable connection between the rods of the anchoring member is formed. The curved rods 52 and 53 have sharp hook-shaped ends. The rod 53 embraces with this end the acromial part of the clavicula from the front and from below, while the rod 52, upon embracing the upper edge of the scapula, is driven with its pointed end into the scapula from behind (not shown). In this position the rods 52 and 53 are tightened and made fast by the nut 48.

The turnbuckle 7 has an anchoring collar 59 with an anchoring screw 60 terminating in a drill-bit to be screwed into the bone.

For each joint the apparatus must have a construction suited to the shape and functional requirements of the joint.

For symmetrical pairs of joints two such apparatus are prepared each as a mirror reflection of the other. The apparatus should be available respectively in three different sizes to suit children, adolescents and adults, and adjustment of the apparatus to suit the particular size of the bone is obtained by means of the adjustably connected parts of the apparatus.

The operation of provisional shaping of the ends of the joints by milling them out of the live bone of the patent in the place of cloven anchylosis or of reconstruction of deformed ends of the joints is performed under general anaesthetic.

After typical resection of soft tissues and the preparation of the place of the lost joint or of the deformed ends of the joint, provisional joint ends are made by milling.

The respective anchoring members of the apparatus are inserted into the two bones forming the joint. In operations on the hip, the curved rods 18 and 19 are inserted into the bone tube 26 of the hip bone and the curved rods 39 and 40 into the pelvis. After that the anchoring members are joined to the remainder of the apparatus, i.e. the turnbuckle 7 is linked up with the curved rods 18 and 19, and the rod 29 of the turnbuckle 30 is held between the jaws 34 and 35. As a result, the curved rod 5 and the curved guiding member 3, movably interconnected by the spherical knob 2, restrict the position of the femoral neck, since the curved rod 5 is fastened to the neck from in front, while the guiding member 3 which is of arcuate shape, restricts the neck from in front and from behind.

By turning the sleeve 8 of the turnbuckle

7 and the sleeve 30 of the turnbuckle 30, and by determining the angle needed for engaging the toothed segments 20 and 37, the correct relative position between the provisional ends of the joint can be established, allowing for the clearance needed for their conjunctive growth.

Having ascertained that the bone ends of the joint are in the best possible position, the surgeon renders the chosen position rigid by tightening the various screws of the apparatus.

If the operation is to be formed on the shoulder joint the operation proceeds in a similar manner to that described for the hip joint, but in this case it is expedient to use the modified apparatus of Figures 5 and 6 where the anchoring member for fixing the apparatus to the scapula and the clavicula consists of the three curved rods 52, 53, 54.

The curved rod 54 is driven into the acromial appendage of the scapula. In the case of a right joint, the rod 53 encircles the arcomial end portion of the clavicula, while the curved rod 52, upon embracing the edge of the scapula from the front and from behind, has its sharp point driven into the bone tissue of the scapula. After that the surgeon chooses the suitable angle for hooking up the toothed sector 49 with the curved rod 54 and finally tightens the screw 56.

The position of the curved rods 52 and 53 is fixed by the nut 48.

By regulating the length of the turnbuckles 7 and 45 and choosing the suitable angle of engagement for the toothed segments 20 and 49, (Figure 5 and 6) the joint end of the shoulder-bone is set into the best possible kinematic position relative to the provisional joint surface of the scapula. Between the provisional surfaces of the joint there is left a clearance necessary for their conjunctive complementary growth.

Thus, the described regulative adjustment of the position of the apparatus allows the joint ends of the bones to be located in the required position with a sufficient clearance between the provisional facies articularis, essential for their natural congruent and complementary growth which is terminated when the facies articularis become covered with supporting hyaline cartilage of the joint. This occurs about 6 to 12 months after the operation resulting in the provisional formation of a new joint by milling provisional ends of the joint out of the patient's live bone in place of the lost joint or at a certain distance therefrom, where there are muscles or where they may be plastically adapted to bring the new joint into motion by the patient's will.

The post-operational regimen of the patient is free; movements begin in the operated joint immediately after the operation and become gradually greater as the aseptical inflamation subsides. After the removal of the sutures from the skin wound the patient is allowed to go home, where he continues his curative physical exercises.

After the final formation of the joint the apparatus is removed, but for patients older than 60 the apparatus may be retained for life, as it does not interfere with their daily routine.

The orthopaedic endoapparatus particularly described provides the necessary conditions for raising new live supporting articular hyaline cartilage, identical to the natural one, upon the facies articularis provisionally prepared by milling the joint ends of the patient's bones forming the new joint, and thus provides the possibility of growing a new live joint according to predetermined form and function in place of the lost one (anchylosis) or at a certain distance from it. Where the bone is being split, joint ends are provisionally milled, or are plastically adjusted. The apparatus can likewise be used for the reconstruction of deformed shoulder or hip joints. The apparatus mechanises the process of resetting a pathologically dyplastic and congentally luxated hip joint in children and adjusts the position and movements of the ends of the joint during the child's growth until the period of the natural reforming of the joint is completed.

The apparatus can kinematically link underdeveloped joint ends of a child's congenitally luxated hip joint, previously reset with the assistance of the same apparatus, and joints provisionally created by milling new or reconstructed ends of shoulder or hip joints of adult or juvenile patients. The apparatus maintains between the facies articularis, whether they be at rest or are being moved, a clearance necessary for their counterdirected, congruent and complementary natural growth.

In controlling the position and movements of the joint the apparatus does not allow movements that are uncontrolled or unnecessary and permits only those movements around a predetermined point or axes that are required to allow growth of the joint according to predetermined form and function.

Under these conditions patients, enjoying a free regimen, may develop within six to twelve months a new joint, the ends of which are congruent and shaped so as to correspond to the predetermined function of the joint, while the facies articularis of its caput and fossa have been covered by supporting hyaline cartilage 1.5 to 2 mm thick on each surface of the joint. This cartilage has a white, smooth, moist, shiny surface, and has firmly grown together with the underlying bone tissue of the joint ends.

Histological analysis of some fragments of cartilage, taken at the biopsy from a new

joint during the operative removal of the apparatus, show that the facies articularis of the new live joint, grown with the assistance of the apparatus, are actually covered by young hyaline cartilage tissue, which is in some places underdeveloped and forms in other places focal points of newly developing cartilage and bone tissus. The results of histological research permit one to speak of newly developed live articular hyaline cartilage.

Articular hyaline cartilage is the fundamental structural element that serves to distinguish the new live joint from the hitherto known artificial and pathological movabilities between the fragments.

In addition, the new live joint is surrounded by the joint capsule containing the synovial fluid.

The new live shoulder or hip joint, formed with the assistance of the apparatus described can be activated by the patient's will.

After the new joint has been finally formed and the apparatus removed, patients are able to do physical work such as driving motor vehicles.

WHAT WE CLAIM IS:—

1. Orthopaedic endoapparatus intended to allow growth of a new live shoulder or hip joint, reconstruction of a deformed joint or restoration of a pathologically dysplastic and congenitally luxated joint, said apparatus comprising a hinge formed by a substantially spherical knob which is engaged in a curved groove of a guide member, the groove being of arcuate cross-section corresponding to that of the spherical knob, the knob being movable along the groove and being capable of limited pivotal movement relative to the guide member, the spherical knob being connected by a curved rod with one operative end of a turnbuckle, the other operative end of which is adjustably connected to a first anchoring means comprising a pair of interconnected, crossed, curved rods, capable of being introduced into a marrow tube, the guide member being attached to one end of a rod, the other end of which is adjustably connected to second anchoring means comprising interconnected, crossed, curved rods, arranged to be secured to the pelvis or the scapula and clavicula.

2. Endoapparatus in accordance with claim 1, in which the turnbuckle comprises a sleeve having on its outside surface flats for a spanner, the sleeve having a longitudinal throughbore, the middle portion of the bore having a plain cylindrical surface, and the opposite end portions of the bore being threaded with the threads at the respective end portions being of opposite hand, and a respective rod screwed into the sleeve from the opposite ends thereof, each rod having inside the sleeve a plain end portion, the diameter of which is less than the diameter of the longitudinal bore of the sleeve, each rod having a flat extending over a length which includes the whole of its plain end portion and an adjacent part of the threaded portion, said flat reducing the thickness of the said length of the rod by less than half the diameter of the rod, the flats of the two rods being in engagement whereby a preloaded contact is formed between the two rods, and between the rods and the sleeve and the threaded parts of the reduced section are bent away from the longitudinal axis of the sleeve into wedging engagement with the threaded surface of the sleeve, the outer end of one of said rods of the turnbuckle being rigid with the said curved rod connected with the spherical knob, and the outer end of the other of said rods of the turnbuckle terminating in a toothed segment engaged with a projection of one of the curved rods of the first anchoring means, said segment having a tapered aperture which receives a tapered projection of the other curved rod of the first anchoring means, the tapered projection being secured within the tapered aperture of the toothed segment by a screw, said turnbuckle including an anchoring collar having an anchoring screw which terminates in a drill-bit for screwing into the bone.

3. Endoapparatus according to claim 1 or claim 2, wherein the second anchoring means comprises a pair of curved rods, and the rod connecting the guide member with the second anchoring means is threaded and is engaged in a threaded blind bore of a sleeve having on its outer surface flats for a spanner, said sleeve having longitudinal slits in its threaded portion and being surrounded by a collar having a clamping screw terminating in a drill-bit for screwing into the bone, the closed end portion of the sleeve terminating in a spherical knob clamped between a pair of clamping jaws by a clamping screw, the clamping screw of the clamping jaws being engaged in a threaded aperture of a tapered projection of the one of the curved rods forming the second anchoring means, the tapered projection engaging in a tapered aperture in one of the clamping jaws, the other of the clamping jaws terminating in a toothed segment engaged with a projection of the other curved rod forming the second anchoring means.

4. Endoapparatus according to claim 1 or claim 2, in which the second anchor-

ing means comprises three interconnected crossed, curved, rods secured together by a screw.

5. Orthopaedic endoapparatus substantially as hereinbefore described with reference to Figures 1 to 4 or Figures 5 and 6 of the accompanying drawings.

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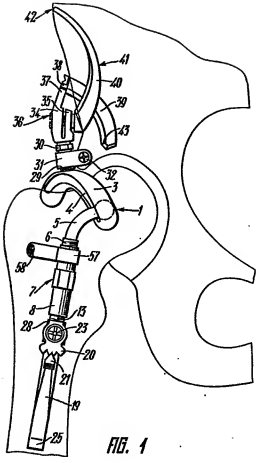

FIG. 1

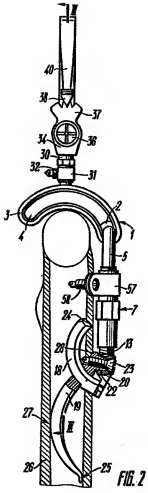
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FIG. 2

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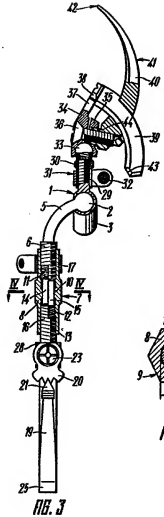

FIG. 3

FIG. 4

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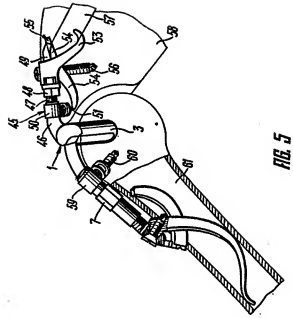

FIG. 5

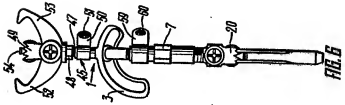

FIG. 6